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(19)

(54) STABILIZATION SYSTEMS FROM TRIARYLPHOSPHITES AND PHENOLS

(71) We, CIBA-GEIGY A.G., a Swiss Body Corporate, of Basle, Switzerland, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to the use of stabilisation systems for triarylphosphites and phenols for stabilising polyolefins against thermooxidative deterioration, as well as to the polyolefins stabilised therewith.

The use of tri-esters of phosphorous acid as stabilisers in polyolefins is known. Furthermore, in J. Voigt, "The Stabilisation of Plastics against Light and Heat", 1st Edition, Springerverlag [Springer publishing house] 1966, page 323, the combination of phosphorous acid esters with other antioxidants is put forward as being their preferred mode of application.

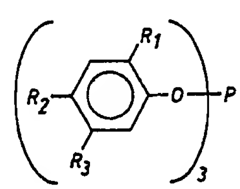
In particular, there is known from US 3,558,554 the use of the three-component combination of "phosphite containing aryl groups"—"phenolic compounds"—"thiodialiphatic esters" in polyolefins.

Among the "phosphites containing aryl groups" there are many variably substituted (unsymmetrical) phosphites, i.e. those which undergo intermolecular transesterification reactions, which are liquid and which readily hydrolyse, which results in poor storage stability and in an inadequate attainable effectiveness. Moreover, with the addition of thiodialiphatic esters under the processing conditions, there is frequently observed discolouration.

It is clear from GB 1,078,772 that the mixture of aryl-containing phosphites with o-substituted phenols in polyolefins exhibits a particularly good stabilising effect. The high degree of effectiveness is attributed to the o-substituent in the phenol component.

In addition, there is described in US 3,533,989 the special two-component combination of 2,6-ditert.butyl-4-methylphenol with Polygard*, (tris-p-nonyl-phenyl phosphites), as a stabiliser for polyolefins. In the same patent specification there is shown the use of tris-(2-tert.butyl-4-methylphenyl)-phosphite, optionally in combination with Polygard. Both combinations contain Polygard, which, as in the case of the above mentioned phosphites, is an oily liquid having the described disadvantages.

It has now been found that, surprisingly, a limited class of symmetrical triarylphosphites of the general formula I



(I)

wherein R_1 represents tert.-butyl, 1,1-dimethylpropyl, cyclohexyl or phenyl, and one of R_2 and R_3 is hydrogen and the other is hydrogen, methyl, tert.-butyl, 1,1-dimethyl-

*tris-(nonylated phenyl)-phosphite

propyl, cyclohexyl or phenyl, display in combination with phenolic antioxidants, and in the absence of a thiosynergist, a particular degree of effectiveness in polyolefins which are polymers or copolymers derived at least in part from singly unsaturated aliphatic hydrocarbons or mixtures of such polymers or copolymers against degradation reactions and cross-linking reactions, such as those normally occurring in the processing of polyolefins.

This particular degree of effectiveness is reflected especially in the excellent absence of discolouration in the resulting polymers, a result which constitutes an advance compared with the results obtained in the case of the prior-art three-component combination described in US 3,558,554. Furthermore, the degree of effectiveness obtained is better than that obtained with the combinations with unsymmetrical phosphites as described in US 3,558,554, or with the combinations with tris-p-nonyl-phenyl phosphite as described in US 3,553,989.

The compounds of the formula I can be used—together with one or more of the phenolic compounds—either singly or in combination with each other. The phosphites usable according to the invention are in most cases crystallised solids, which, compared with the wide range of phosphites known hitherto, are particularly stable also against hydrolysis.

The symbols in the formula I preferably have the following meanings:

R_1 represents tert.-butyl of 1,1-dimethylpropyl, and one of

R_2 and R_3 represents hydrogen, and the other represents hydrogen, methyl, tert.-butyl or 1,1-dimethylpropyl.

A particularly preferred embodiment is one wherein

R_1 represents tert.-butyl, and one of

R_2 and R_3 represents hydrogen, and the other represents hydrogen, methyl or tert.-butyl.

Compounds of the formula I that are especially suitable are, for example:

tris-(2,5-ditert.-butylphenyl)-phosphite,
tris-(2-tert.-butylphenyl)-phosphite,
tris-(2-phenylphenyl)-phosphite,
tris-[2-(1,1-dimethylpropyl)-phenyl]-phosphite,
tris-[2,4-di-(1,1-dimethylpropyl)-phenyl]-phosphite,
tris-(2-cyclohexylphenyl)-phosphite, and
tris-(2-tert.-butyl-4-phenylphenyl)-phosphite;
or, in particular:
tris-(2,4-ditert.-butylphenyl)-phosphite.

The following are be mentioned as examples of phenolic compounds:

1. *Single 2,6-dialkylphenols*, such as
2,6-di-tert.-butyl-4-methylphenyl, 2,6-di-tert.-butyl-4-methoxymethylphenol or 2,6-di-tert.-butyl-4-methoxyphenyl.

2. *Bisphenols*, such as
2,2′-methylene-bis-(6-tert.-butyl-4-methylphenol), 2,2′-methylene-bis-(6-tert.-butyl-4-ethylphenol), 2,2′-methylene-bis-[4-methyl-6-(α-methylcyclohexyl)-phenol], 1,1 - bis - (5 - tert. - butyl - 4 - hydroxy - 2 - methylphenyl) - butane, 2,2 - bis - (5 - tert.-butyl - 4 - hydroxy - 2 - methylphenyl) - butane, 2,2 - bis-(3,5 - di - tert.butyl - 4 - hydroxyphenyl) - propane, 1,1,3 - tris - (5 - tert.-butyl - 4 - hydroxy - 2 - methylphenyl) - butane, 2,2 - bis - (5 - tert. - butyl-4 - hydroxy - 2 - methylphenyl) - 4 - n - dodecylmercapto - butane, 1,1,5,5-tetra - (5 - tert.-butyl - 4 - hydroxy - 2 - methylphenyl) - pentane, ethylene glycol - bis [3,3 - bis - (3′ - tert.-butyl - 4′ - hydroxyphenyl) - butyrate], 1,1-bis - (3,5 - dimethyl - 2 - hydroxyphenyl) - 3 - (n - dodecylthio) - butane, or 4,4′ - thio - bis - (6 - tert.-butyl - 3 - methylphenol).

3. *Hydroxybenzyl compounds*, such as
1,3,5 - tri - (3,5 - di - tert.-butyl - 4 - hydroxybenzyl) - 2,4,6 - trimethylbenzene, 2,2 - bis - (3,5 - di - tert. - butyl - 4 - hydroxybenzyl) - malonic acid - dioctadecyl ester, 1,3,5 - tris - (3,5 - di - tert.-butyl - 4 - hydroxybenzyl) - isocyanurate, or 3,5 - di - tert.-butyl - 4 - hydroxybenzyl - phosphonic acid-diethyl ester.

4. *Amides of β-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionic acid,* such as 1,3,5 - tris - (3,5 - di - tert.-butyl - 4 - hydroxyphenyl - propionyl) - hexahydro-s-triazine, N,N' - di - (3,5 - di - tert.butyl - 4 - hydroxyphenyl - propionyl)-hexamethylenediamine.

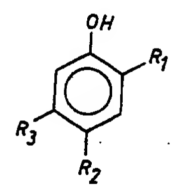
5. *Esters of β-(3,5-di-tert.butyl-4-hydroxyphenyl)-propionic acid* with mono- or poly-valent alcohols, such as with methanol, octadecanol, 1,6-hexanediol, ethylene glycol, thiodiethylene glycol, neopentyl glycol, pentaerythritol, tris-hydroxyethyl-isocyanurate.

6. *Spiro compounds,* such as diphenolic spiro-diacetals or spiro-diketals, such as 2,4,8,10-tetraoxaspiro-[5,5]-undecane substituted in the 3- and 9-position with phenolic radicals, such as 3,9-bis - (3,5 - di - tert.butyl - 4 - hydroxyphenyl) - 2,4,8,10 - tetraoxaspiro - [5,5]-undecane, 3,9 - bis - [1,1 - dimethyl - 2 - (3,5 - ditert.-butyl - 4 - hydroxy-phenyl) - ethyl] - 2,4,8,10 - tetroxaspiro - [5,5] - undecane.

Particularly preferred phenolic compounds are:

1,3,5 - tri - (3,5 - di - tert.-butyl - 4 - hydroxybenzyl) - 2,4,6 - tri - methylbenzene,
pentaerythritol - tetra[3 - (3,5 - di - tert.-butyl - 4 - hydroxyphenyl) - propionate],
β - (3,5 - di - tert. - butyl - 4 - hydroxyphenyl) - propionic acid - n - octadecyl ester,
thiodiethylene glycol - β - [4 - hydroxy - 3,5 - di - tert.-butyl - phenyl] - propionate,
2,6 - di - tert.-butyl - 4 - methyl - phenol, and
3,9 - bis - [1,1 - dimethyl - 2 - (3,5 - ditert.-butyl - 4 - hydroxyphenyl) - ethyl]-2,4,8,10 - tetraoxaspiro - [5,5] - undecane.

The compounds of the formula I can be produced by methods known per se, for example by reaction of a phenol of the formula II



(II)

with phosphorus trichloride, without solvent, at 20—250° C., or in an inert aprotic solvent in the presence of an organic base, or by reaction of a compound of the formula II with triphenylphosphite, preferably without solvent, in the presence of a basic catalyst.

The resulting compounds are purified by recrystallisation in a suitable solvent (solvent mixture).

It is possible with the stabiliser mixture according to the invention to stabilise, for example, the following polyolefins:

1. polymers that are derived from singly unsaturated hydrocarbons, such as polyolefins, e.g. polyethylene of low and high density, which can optionally be cross-linked, polypropylene, polyisobutylene, polymethylbutene-1 and polymethylpentene-1;
2. mixtures of the homopolymers mentioned under 1., such as mixtures of polypropylene and polyethylene, polypropylene and polybutene-1, polypropylene and polyisobutylene;
3. copolymers of the monomers on which the homopolymers mentioned under 1. are based, such as ethylene/propylene copolymers, propylene/butene-1 copolymers, propylene/isobutylene copolymers, ethylene/butene-1 copolymers, as well as terpolymers of ethylene and propylene with a diene, such as hexadiene, di-cyclopentadiene or ethylideneorbornene.

The stabiliser mixture according to the invention is incorporated at a concentration of 0.005% to 5%, preferably 0.01 to 1%, particularly preferably 0.05 to 0.5%, calculated on the weight of the material to be stabilised. The triarylphosphite and the phenolic antioxidant are incorporated in the weight ratio of 10:1 to 1:5, preferably

5:1 to 1:2, particularly 3:1 to 1:1. Incorporation can be effected by various methods, for example by dry mixing of the polymer with at least one of the compounds of the invention and a phenolic antioxidant, and subsequent processing in a kneading machine, mixing rolls or extruder. The additives mentioned can be applied also in the form of a solution or dispersion to the polymer, with the solvent being subsequently evaporated off.

The amount of compound of the general formula I is preferably from 0.05 to 0.15% by weight based on the weight of the polyolefin.

The following may be mentioned as examples of further additives that can be used together with the combination according to the invention:

1 *Aminoaryl derivatives*, e.g.
phenyl-1-naphthylamine, phenyl-2-naphthylamine, N,N'-di-phenyl-p-phenylenediamine, N,N'-di-2-naphthyl-p-phenylenediamine, N,N'-di-2-naphthyl-p-phenylenediamine, N,N'-di-sec.-butyl-p-phenylenediamine, 6-ethoxy-2,2,4-trimethyl-1,2-dihydroquinoline, 6-dodecyl-2,2,4-trimethyl-1,2-dihydroquinoline, mono- and dioctyliminodibenzyl, polymerised 2,2,4-trimethyl-1,2-dihydroquinoline.

Octylated diphenylamine, nonylated diphenylamine, N-phenyl-N'-cyclohexyl-p-phenylenediamine, N-phenyl-N'-isopropyl-p-phenylenediamine, N,N'-di-sec.octyl-p-phenylenediamine, N-phenyl-N'-sec.-octyl-p-phenylenediamine, N,N'-di-(1,4-dimethylpentyl)-p-phenylenediamine, N,N'-dimethyl-N,N'-di-(sec.-octyl)-p-phenylenediamine, 2,6-dimethyl-4-methoxyaniline, 4-ethoxy-N-sec.-butylaniline, diphenylamineacetone condensation product, adol-1-naphthylamine and phenothiazine.

With the use of this group, discolouration effects have to be taken into account.

2. *UV-Absorbers and light-stabilising agents*
2.1. *2-(2'-Hydroxyphenyl)-benzotriazoles*, e.g. the 5'-methyl-, 3',5'-di-tert.-butyl-, 5'-tert.-butyl-, 5'-(1,1,3,3-tetramethylbutyl)-, 5-chloro-3',5'-di-tert.-butyl-, 5-chloro-3'-tert.-butyl-5'-methyl-, 3'-sec.-butyl-5'-tert.-butyl-, 3'-α-methylbenzyl-5'-methyl-, 3'-α-methylbenzyl-5'-methyl-5-chloro-, 4'-hydroxy-, 4'-methoxy-,4'-octoxy-, 3',5'-di-tert.-amyl-, 3'-methyl-5'-carbomethoxyethyl- and 5-chloro-3',5'-di-tert.-amyl-derivative.
2.2 *2,4-bis-(2'-Hydroxyphenyl)-6-alkyl-s-triazines*, e.g. the 6-ethyl-, 6-heptadecyl- or 6-undecyl-derivative.
2.3 *2-Hydroxybenzophenones*, e.g. the 4-hydroxy-, 4-methoxy, 4-octoxy, 4-decyloxy, 4-dodecyloxy-, 4-benzyloxy-, 4,2',4'-trihydroxy- or 2'-hydroxy-4,4'-dimethoxy-derivative.
2.4. *1,3-bis-(2'-Hydroxybenzoyl)-benzenes*, e.g.
1,3-bis-(2'-hydroxy-4'-hexyloxy-benzoyl)-benzene, 1,3-bis-(2'-hydroxy-4'-octyloxy-benzoyl)-benzene or 1,3-bis-(2'-hydroxy-4'-dodecyloxy-benzoyl)-benzene.
2.5. *Esters of optionally substituted benzoic acids*, e.g.
phenylsalicylate, octylphenylsalicylate, dibenzoylresorcin, bis-(4-tert.-butylbenzoyl)-resorcin, benzoylresorcin, 3,5-di-tert.-butyl-4-hydroxybenzoic acid-2,4-di-tert.-butyl-phenyl ester or -octadecyl ester or -2-methyl-4,6-di-tert.-butyl ester.
2.6. *Acrylates*, e.g.
α-cyano-β,β-diphenylacrylic acid-ethyl ester or -isooctyl ester, α-carbomethoxy-cinnamic acid methyl ester, α-cyano-β-methyl-p-methoxy-cinnamic acid methyl ester or -butyl ester or N-(β-carbomethoxyvinyl)-2-methyl-indoline.
2.7. *Nickel compounds*, e.g.
nickel complexes of 2,2'-thio-bis-[4-(1,1,3,3-tetramethylbutyl)-phenol], such as the 1:1- or 1:2-complex optionally with additional ligands such as n-butylamine, triethanolamine or N-cyclohexyl-di-ethanolamine, nickel complexes of bis-[2-hydroxy-4-(1,1,3,3-tetramethylbutyl)-phenyl]-sulphone, such as the 2:1-complex, optionally with additional ligands such as 2-ethylcapronic acid, nickeldibutyldithiocarbamate, nickel salts of 4-hydroxy-3,5-di-tert.-butylbenzyl-phosphonic acid-monoalkyl esters, such as of methyl, ethyl or butyl esters, nickel complexes of ketoximes, such as of 2-hydroxy-4-methyl-phenyl-undecylketonoxime, nickel-3,5-di-tert.-butyl-4-hydroxybenzoate or nickel-isopropylxanthogenate.
2.8 *Sterically hindered amines*, e.g.
4-benzoyl-2,2,6,6-tetramethylpiperidine, 4-stearoyloxy-2,2,6,6-tetramethylpiperidine, bis-(2,2,6,6-tetramethylpiperidyl)-sebacate or 3-n-octyl-7,7,9,9-tetramethyl-1,3,8-triaza-spiro[4,5]decane-2,4-dione.
2.9. *Oxalic acid diamides*, e.g.
4,4'-di-octyloxy-oxanilide, 2,2'-di-octyloxy-5,5'-di-tert.-butyl-oxanilide, 2,2'-di-dodecyloxy-5,5'-di-tert.-butyl-oxanilide, 2-ethoxy-2'-ethyl-oxanilide, N,N'-bis-(3-dimethylaminopropyl)oxalamide, 2-ethoxy-5-tert.-butyl-2'-ethyl-oxanilide and the mixtures thereof with 2-ethoxy-2'-ethyl-5,4'-di-tert.-butyl-oxanilide, or mixtures of ortho- and para-methoxy- as well as of o- and p-ethoxy-disubstituted oxanilides.

3. *Metal deactivators,* e.g.
oxanilide, isophthalic acid dihydrazide, sebacic acid-bis-phenylhydrazide, bis-benzylidene-oxalic acid dihydrazide, N,N'-diacetal-adipic acid dihydrazide, N,N'-bis-salicyloyl-oxalic acid dihydrazide, N,N'-bis-salicyloylhydrazine, N,N'-bis-(3,5-di-tert.-butyl-4-hydroxyphenylpropionyl)hydrazine, N-salicyloyl-N'-salicylalhydrazine, 3-salicyloyl-amino-1,2,4-triazole or N,N'-bis-salicyloyl-thiopropionic acid dihydrazide.

4. *Basic co-stabilisers,* e.g.
alkali metal salts and alkaline-earth metal salts of higher fatty acids, for example Ca-stearate, Zn-stearate, Mg-behenate, Na-ricinoleate or K-palmitate.

5. *Nucleation agents,* e.g.
4-tert.-butylbenzoic acid, adipic acid or diphenylacetic acid.

6. *Other additives,* e.g.
lubricants, e.g. particularly preferred: stearyl alcohol, fillers, carbon black, asbestos, kaolin, talcum, glass fibres, pigments, optical brighteners, flameproofing agents and antistatic agents.

The invention is further illustrated in the following Examples I and II to VII. Percentages (%) denote therein per cent by weight, calculated on the material to be stabilised.

Example I.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form BASF) ("Lupolen" is a Registered Trade Mark) are in each case mixed dry with 0.05 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate] and 0.1 part of a stabiliser of the following Table 1 or 2. The mixtures are kneaded in a Brabender plastograph at 220° C. and at 50 r.p.m. for 20 minutes. During this time, the resistance to kneading is continuously recorded as a torsional moment. Owing to cross-linking of the polymer, there occurs during the kneading period, after an initial constant stage, a rapid increase of the torsional moment. The effectiveness of the stabilisers is reflected in a lenghening of the time of constant torsional moment.

The mixtures are subsequently removed from the plastograph and pressed out in a platen press at 260° platen temperature to sheets 1 mm thick, the appearance of which is visually assessed with respect to colour. For the assessment of discolouration in Tables 1 and 2, there is used an empirical colour scale wherein 5 denotes colourlessness, 4 a just perceptible discolouration, and 3, 2, 1 and <1 denote a successively more severe discolouration.

TABLE 1

Effectiveness of the stabiliser combinations of the invention

Phosphite stabiliser	Time in minutes until change of torsional moment	Discolouration assessment of the sheet specimens
none	3 1/2	5
tris-(2,4-di-tert.-butylphenyl)-phosphite	10	4–5
tris-(2-tert.-butyl-4-methylphenyl)-phosphite	10 1/2	4
tris-(2-tert.-butyl-5-methylphenyl)-phosphite	9	4

TABLE 2

Effectiveness of the unsymmetrical triphosphites described in US 3,558,554

Phosphite stabiliser	Time in minutes until change of torsional moment	Discolouration assessment of the sheet specimens
none	3 1/2	5
di-n-butyl-(2-tert.-butyl-4-methyl-phenyl)-phosphite	4	4
di-phenyl-(2-tert.-butyl-4-methyl-phenyl)-phosphite	4 1/2	4–5
di-n-butyl-(2,6-di-tert.-butyl-4-methyl-phenyl)-phosphite	6 1/2	2 (speckled inhomogeneous)

From the results shown in Tables 1 and 2 it is clear that, compared with the comparative products given in Table 2, the triarylphosphites of the formula I in Table I display in polyolefins a very high degree of effectiveness. In particular the concomitant use of dilaurylthiodipropionate leads to a plastics material having poor colour properties.

Example II.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form from BASF) are in each case mixed dry with 0.1 part of dilaurylthiodipropionate and with the stabilisers shown in the following Table 3. The mixtures are kneaded in a Brabender plastograph at 220° C. and 50 r.p.m. for 20 minutes. During this time, the resistance to kneading is continuously recorded as a torsional moment. As a consequence of cross-linking of the polymer there occurs in the course of kneading, after an initial constant condition, a rapid rise of the torsional moment. The effectiveness of the stabilisers is expressed in a lengthening of the time of constant torsional moment. The mixtures are subsequently removed from the plastograph and pressed out in a platen press at 260° C. platen temperature into the form of 1 mm thick sheets, the appearance of which is visually assessed with respect to colour. For the assessment of discolouration in Table 3, there is used an empirical colour scale wherein 5 denotes colourlessness, 4 denotes a slight discolouration just perceptible, and 3, 2, 1 and <1 denote a successively more severe discolouration.

TABLE 3

Parts of stabiliser	Time in minutes until change of torsional moment	Discolouration assessment of the sheet specimens
0.05 part of pentaerythritol-tetra-3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate	2 1/2	1
0.05 part of pentaerythritol-tetra-3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate + 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	5	<1
0.05 part of pentaerythritol-tetra-3-(3,5-ditert.-butyl-4-hydroxyphenyl)-propionate + 0.1 part of tris-(2,4-ditert.-butyl-phenyl)-phosphite	6	<1
0.05 part of 1,1,3-tris-(5-tert.-butyl-4-hydroxy-2-methylphenyl)-butane	5 1/2	<1
0.05 part of 1,1,3-tris-(5-tert.-butyl-4-hydroxy-2-methylphenyl)-butane + 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	9	<1
0.05 part of 2,6-di-tert.-butyl-4-methylphenol	5	<1
0.05 part of 2,6-di-tert.-butyl-4-methylphenol + 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	10 1/2	<1

The results show that, independent of the employed antioxidant, there is obtained with the concomitant use of dilaurylthiodipropionate a plastics material which has poor colour properties and which gives in some cases low times of constant torsional moment.

Example III.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form from BASF) are mixed dry with the stabilisers of the following Table 4 in the given concentrations. The mixtures are kneaded in a Brabender plastograph at 220° C. and 50 r.p.m. for 20 minutes. During this time the resistance to kneading is continuously recorded. As a consequence of cross-linking of the polymer, there occurs in the course of the kneading process, after

an initial constant condition, a rapid rise in the torsional moment. The effectiveness of the stabilisers is expressed in a lengthening of the time of constant torsional moment.

TABLE 4

Parts of stabiliser	Time in minutes to change of the torsional moment
none	2
0.15 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate]	6
0.15 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	4
0.05 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate]	10 1/2
+ 0.10 part of tris-2-tert.-butyl-4-methylphenyl)-phosphite	

It follows from the data that with the same total concentration the combination according to the invention produces a protective effect that is clearly better compared with that obtained with the stabilisers used separately.

Example IV.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form from BASF) are in each case mixed dry with 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite and 0.05 part of the phenolic antioxidants shown in the following Table 5. The mixtures are kneaded in a Brabender plastograph at 220° and 50 r.p.m. for 20 minutes. During this time, the resistance to kneading is continuously recorded as a torsional moment. As a consequence of cross-linking of the polymer there occurs in the course of kneading, after an initial constant phase, a rapid rise of the torsional moment. The effectiveness of the stabilisers is expressed in a lengthening of the time of constant torsional moment.

TABLE 5

Phenolic antioxidant	Time in minutes to change of the torsional moment
none	4
pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate	10 1/2
1,1,3-tris-(5-tert.-butyl-4-hydroxy-2-methylphenyl)-butane	8
3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionic acid-octadecyl-ester	7
1,3,5-tri-(3,5-di-tert.-butyl-4-hydroxybenzyl)-2,4,6-trimethylbenzene	8
2,2'-methylene-bis-(6-tert.-butyl-4-4-methylphenol)	10
4,4'-thiobis-(6-tert.-butyl-3-methylphenol)	11

The results show that with a wide selection of phenolic compounds in combination with the triarylphosphites according to the invention there is obtained an excellent stabilisation of polyethylene of high density.

Example V.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form from BASF) are mixed dry with the stabilisers given in Table 6 at the given concentrations. The mixtures are kneaded in a Brabender plastograph at 220° C. and 50 r.p.m. for 20 minutes. The resistance to kneading during this time is continuously recorded as a torsional moment. As a consequence of cross-linking of the polymer there occurs in the course of kneading, after an initial constant condition, a rapid increase of the torsional moment. The effectiveness of the stabilisers is expressed in a lengthening of the time of constant torsional moment.

TABLE 6

Effectiveness of the stabiliser combinations according to the invention compared with that of the systems described in US 3,533,989.

Parts of stabiliser	Time in minutes until change of the torsional moment
0.05 part of 2,6-ditert.-butyl-4-methylphenol + 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	10
0.05 part of 2,6-ditert.-butyl-4-methylphenol + 0.1 part of tris-(2,4-ditert.-butylphenyl)-phosphite	12
0.05 part of 2,6-ditert.-butyl-4-methylphenol + 0.1 part of Polygard (tris-p-nonylphenyl)-phosphite	5
0.15 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite	4

Example VI.

100 parts of unstabilised polyethylene of high density having a molecular weight of about 500,000 ("Lupolen 5260 Z" in powder form from BASF) are mixed dry with 0.05 part of 3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionic acid-octadecyl ester and 0.1 part of tris-(2-tert.-butyl-4-methylphenyl)-phosphite.

250 kg of this mixture is processed in an extrusion-blow apparatus (Type VB 250, VOITH) at 227° C. nozzle temperature into the form of 120-litre barrels (frequency: 10 minutes per shot; 1 shot: 10 kg of material). The barrels have a smooth inner surface and are free of lattice or honey-comb structure. Lattice or honey-comb structure or a rough inner surface are the result of an occurring cross-linking of the material.

Example VII.

100 parts of polypropylene powder (Propathene HF 20, ICI) ("Propathene" is a Registered Trade Mark) are homogeneously mixed with the stabilisers listed in the following Table 7 at the stated concentrations. The mixtures obtained are extruded and granulated five times in succession in a single screw extruder at a maximum of 260° C. (temperature of the discharge zone) and 100 r.p.m.

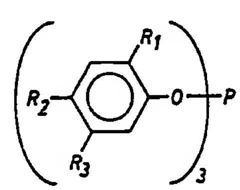
The melt index of the material is measured after the 1st, 3rd and 5th extrusion. The load is 2160 g at 230° C.; the melt index is given in g/10 min. The degradation of the material is indicated by an increase of the melt index.

TABLE 7

Parts of stabiliser	Melt index after given number of extrusions		
	1	3	5
none	14	42	76
0.15 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate]	4.8	6.5	9.0
0.15 part of tris-(2,4-di-tert.-butylphenyl)-phosphite	4.0	8.0	12.3
0.075 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate] + 0.075 part of tris-(2,4-di-tert.-butylphenyl)-phosphite	3.5	5.0	7.4
0.05 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate] + 0.1 part of tris-(2,4-di-tert.-butylphenyl)-phosphite	3.3	4.9	6.6
0.03 part of pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate + 0.12 part of tris-(2,4-di-tert.-butylphenyl)-phosphite	3.2	4.5	6.5
0.15 part of 3,9-bis-[1,1-di-methyl-2(3,5-di-tert.-butyl-4-hydroxyphenyl)-ethyl]2,4,8,10-tetraoxaspiro-[5,5]undecane	4.9	6.8	9.0
0.05 part of 3,9-bis-[1,1-di-methyl-2(3,5-di-tert.-butyl-4-hydroxyphenyl)-ethyl]2,4,8,10-tetraoxaspiro-[5,5]undecane + 0.1 part of tris-(2,4-di-tert.-butylphenyl)-phosphite	3.4	4.5	6.2

WHAT WE CLAIM IS:—

1. A composition comprising a polyolefin which is a polymer or copolymer derived at least in part from a singly unsaturated aliphatic hydrocarbon or a mixture of such polymers or copolymers and from 0.005 to 5% by weight based on the weight of polyolefin of at least one symmetrical triarylphosphite of the general formula I



(I)

wherein

R_1 represents tert.-butyl, 1,1-dimethylpropyl, cyclohexyl or phenyl, and one of R_2 and R_3 represents hydrogen, and the other represents hydrogen, methyl, tert.-butyl, 1,1-dimethylpropyl, cyclohexyl or phenyl, in combination with a phenolic anti-oxidant in which the weight ratio of triarylphosphite to phenolic antioxidant is from 10:1 to 1:5 and in the absence of a thiosynergist.

2. A composition according to Claim 1, characterised in that in the formula I R_1 represents tert.-butyl and one of R_2 and R_3 represents hydrogen, and the other represents hydrogen, methyl or tert.-butyl.

3. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is an ester of β-(3,5-di-tert.butyl-4-hydroxyphenyl)-propionic acid.

4. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is pentaerythritol-tetra-[3-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionate].

5. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is β-(3,5-di-tert.-butyl-4-hydroxyphenyl)-propionic acid-n-octa-decyl ester.

6. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is a hydroxybenzyl compound.

7. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is 1,3,5-tri-(3,5-di-tert.butyl-4-hydroxybenzyl)-2,4,6-trimethyl-benzene.

8. A composition according to Claim 1 or Claim 2 characterised in that the phenolic antioxidant is 3,9-bis-[1,1-dimethyl-2(3,5-di-tert.butyl-4-hydroxyphenyl-ethyl]-2,4,8,10-tetraoxaspiro-[5,5]-undecane.

9. A composition according to Claim 1 characterised in that the compound of formula I is tris-(2,4-di-tert.-butylphenyl)-phosphite and the phenolic antioxidant is 3,9 - bis - [1,1 - dimethyl - 2(3,5 - di - tert - butyl - 4 - hydroxyphenyl - ethyl]-2,4,8,10-tetraoxaspiro-[5,5]-undecane.

10. A composition according to any of the preceding Claims, characterised in that stearyl alcohol is used as additional additive.

11. A composition according to any of the preceding claims characterised in that the amount of compound of the general formula I is from 0.05% to 0.15% by weight based on the weight of the polyolefin.

12. A composition according to any of the preceding claims in which the poly-olefin is polyethylene.

13. A composition according to any of Claims 1 to 11 in which the polyolefin is polypropylene.

14. A composition according to Claim 1 substantially as described in any of Examples 1 and 3 to 6.

15. A composition according to Claim 1 substantially as described in Example 7.

16. A process for stabilising polyolefins, characterised in that from 0.005 to 5% by weight based on the weight of polyolefin of a symmetrical triarylphosphite of the general formula I according to Claim 1 in combination with a phenolic antioxidant in a weight ratio of 10:1 to 1:5 is incorporated into the polyolefin.

17. A process according to Claim 16 substantially as described in any of Examples 1 and 3 to 6.

18. A process according to Claim 16 substantially as described in Example 7.

19. A mixture containing a symmetrical triaryl phosphite of the general formula I and a phenolic antioxidant in a weight ratio of 10:1 to 1:5.

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